Journal Home: www.biospub.com

Popular Article

Article: RT952

Biotica Research Today
Vol 4:3
2022
241/243

Genetic Improvement Program in Fisheries: Indian Scenario

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Open Access

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Keywords

Aquaculture, Carps, Genetic improvement, Selective breeding

Article History

Received on: 08th April 2022

Revised on: 11th April 2022

Accepted on: 12th April 2022

E-mail: bioticapublications@gmail.com

How to cite this article?

Kumar and Debbarma, 2022. Genetic Improvement Program in Fisheries: Indian Scenario. Biotica Research Today 4(3): 241-243.

Abstract

There is growing need for genetic research on different tropical fish species to close the looming gap between demand for and supply of food fish. Most of the aquaculture stocks in current use are generally similar to wild undomesticated stocks and in some situations there is evidence for genetic deterioration. It has been widely assumed that genetic intervention will require extensive resources and, the ultimate goal of every genetic improvement programme is to manipulate fish genes to produce better phenotype; therefore, should be considered as an option for the future. Aquaculture genetics research in India is relatively recent. Initially, research was limited to production and evaluation of carp hybrids. There are some methods by which it can be done like Selective breeding, Hybridization, Genetic characterization, Gene mapping *etc*. In India, some of fisheries research institute is involved in this genetic improvement programmes.

Introduction

Aquaculture genetics research in India is relatively recent. Initially, research was limited to production and evaluation of carp hybrids. Among the Indian carp species, as many as six interspecific and 13 intergeneric hybrids have been produced. Besides these, hybrid crosses were also made between Indian and Chinese grass carp, silver carp and Common carp. The crosses between common carp and Indian carp resulted in sterile hybrids. Methodologies for chromosomal engineering, leading to gynogenesis and polyploidy (triploidy and tetraploidy), were also developed for Indian and Chinese carps for application in aquaculture. Sex manipulation of fish, particularly in Tilapia and Common carp, were also carried out successfully. A survey of some carp seed producing hatcheries in India indicated inbreeding. Selective breeding work was undertaken in Rohu (*Labeo rohita*) and Catla (*Catla catla*) to produce genetically improved seed and to develop proper breeding procedures for the hatchery managers in the country to avoid inbreeding in hatchery stocks (Ayyappan *et al.,* 2019).

Inland aquaculture in India is centered on carps, *i.e.*, Indian major carps, catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*), Chinese carps and Common carp (*Cyprinus carpio*). Until the mid-1950's, fish culturists depended on wild collections of Indian Carps seed from rivers. However, the success of Hypophysation technique made spawning these fish under captivity possible. This has helped farmers in procuring seed from hatcheries. Hence, it became essential to carry out research on genetic improvement of these carps through various approaches. In the 1960's and 1970's, fish genetic research was mainly restricted to cytogenetic studies and hybridization. Later, chromosome manipulation, developing breeding programs for important carp species and application of molecular techniques were emphasized. Several national and central institutions and State Agricultural and other Universities undertake fish genetic research. Some of these are the Central Institute of Freshwater Aquaculture (CIFA), National Bureau of Fish Genetic Resources (NBFGR), Central Institute of Fisheries Education (CIFE), University of Agricultural Sciences (UAS), Bangalore (at Fisheries Research Station, Hesaraghatta, and College of Fisheries, Mangalore), Centre for Cellular and Molecular Biology (CCMB), Madhurai Kamraj University (MKU) and Bose Institute.

1. Hybridization

When two different species, genera or families can be crossed and the first filial generation then crossed, backcrossed or outcrossed to give the hybrid of desired qualities.

In any genetic/ stock improvement program, it is necessary to breed the candidate species artificially under controlled conditions. The success of induced breeding of Indian major carps paved the way for research on genetic improvement of carps (Sarkar *et al*., 2018). In the initial stages, simple interspecific and intergeneric hybridization was done to produce and evaluate the carps useful traits for aquaculture. Hybridization is one of the methods used for combining desirable traits of selected species, with experiments demonstrating a high level of compatibility among Indian carps.

Altogether, 6 interspecific and 13 intergeneric hybrids were produced among the four species of Indian major carps belonging to three genera, *i.e*., *Catla, Labeo* and *Cirrhinus*. Over three decades of research on hybridization showed that these major carps with distinct morphological characters are highly compatible and able to produce viable and fertile hybrid progenies. Mature interspecific and intergeneric hybrids could be induced to produce F2 progeny or backcross and triple-cross hybrids. The growth exhibited by most of these hybrids was intermediate, *i.e.*, better than the slow-growing parent as in the case of interspecific hybrid between *L. rohita* and *L. calbasu* or intergeneric hybrids between *L. rohita* and *C. catla* or *C. catla* and *C. mrigala*, *etc*. Hybridization between Indian major carps (*C. catla* and *L. rohita*) and medium carp *L. fimbriatus* also had a similar trend in growth with hybrids showing superiority over slow-growing parents. With regard to hybridization between Indian major carps and Chinese grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Aristichthys nobilis*), no compatibility was observed. Almost all of these died either during the embryonic development or soon after hatching. Only a few hybrids between *C. catla* and *H. molitrix* survived.

Relatively better survival of the hybrid progeny was observed in the crosses between female common carp (*C. carpio*) and males of *C. catla*, *L. rohita* and *C. mrigala* compared with the reciprocal hybrid crosses particularly between female *L. rohita* and male *C. carpio.* It is necessary to prevent indiscriminate hybridization. These carps are highly compatible to interbreed. Also, since almost all interspecific and intergeneric hybrids were found fertile, one should be more cautious of their crossbreeding as this may cause serious damage to the original gene pool through genetic introgression.

2. Selective Breeding

A. Jyanti rohu

Selective breeding is a breeding programme that tries to improve the breeding value of the population by selecting and mating only the best fish (largest, heaviest, those with the desired colour, *etc*.) in the hope that the select brood fish will be able to transmit their superiority to their offspring.

CIFA, in collaboration with the Institute of Aquaculture Research of Norway (AKVAFORSK), undertook genetic improvement of *L. rohita* through selective breeding. The project started in 1992, and the first phase was completed in 1997. The second phase is in progress. *L. rohita* was chosen as the model fish, not only because of consumer preference, but also because of its poor growth in many polyculture systems. Besides, *L. rohita* is also prone to disease, particularly parasitic infection.

The founder population of *L. rohita* was collected as fry/ fingerlings from five different rivers, *i.e*., Ganga, Gomati, Yamuna, Sutlej and Brahmaputra, in addition to CIFA hatchery stocks. The stocks were marked by M-prucian blue dye marking/ fin clipping for communal rearing in the same pond to raise them to brood-fish. After nearly one year of rearing, estimation of breeding value was done following combined selection. Individuals were ranked according to their breeding value and the top 300-500 individuals were selected as brood-fish for the next generation. Individuals with breeding value around the mean value were taken as control groups.

Realized selection responses were calculated after each generation of selection for first and second line base populations. Since genotype interacts sensitively with environment, these findings have to be tested under different agro-climatic conditions in the country. Field experiments to this effect were started in Ludhiana (Punjab), Bangalore (Karnataka), Vijaywada (Andhra Pradesh) and Kausalyaganga State Fish Farm (Orissa). Genetically improved *L. rohita* was supplied to some carp hatcheries in India to replace their broodstock. Studies for formulation of effective feed for improved *L. rohita* are in progress.

B. Catla catla

In 1995, a research program to assess the genetic status of Indian major carps with reference to *C. catla* and to start a sustainable breeding program was initiated at the Fisheries

Research Station, Kakinada, in collaboration with the Fish Genetic Program of the University of Wales, UK. A survey on broodstock management and breeding practices by major carp hatcheries revealed that these hatcheries function as isolated units. The survey also indicated that the stocks are likely to be inbred and that their performance will possibly decline if corrective measures are not taken. Germplasm from four wild stocks were collected and will be evaluated. Progress has been slow due to late maturity (3+ years) and difficulty in getting simultaneously ripe breeders of all stocks.

C. Macrobrachium rosenbergii

Macrobrachium rosenbergii is one of the widely cultured freshwater prawn species globally. India was the third largest producer of this species in 2007 and its aquaculture production rose to 43,000 metric tons (t) in 2005 from less than 500 t in 1995. However, since then production has been declining and in 2008-09 it was 12,856 t, a reduction of more than 70% compared to 2005. There are several contributing factors to this decline, such as slow growth rate, poor survival, disease outbreaks, increase in cost of production, and availability of low risk alternative fish species. However, there is a consensus that poor seed quality leading to unsatisfactory growth and survival rates in ponds is one of the major reasons. Hence, the development of a systematic selective breeding program aimed at improving growth rate and ensuring high survival rate of this species was deemed a high priority. The Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar, India in collaboration with the World Fish Center, Malaysia initiated a selective breeding program for this species in 2007 (Pillai *et al*., 2011). Now in 2020 sixth generation is produced, selectively bred prawns outperformed the control stocks in all the tested sites.

3. Genetic Characterization

In genetic terms, characterization refers to the detection of variation as a result of differences in either DNA sequences or specific genes or modifying factors. Identification and genetic characterization of wild and hatchery populations are important since broodstock with good genetic background is necessary for a successful breeding program. The knowledge from such investigations can be used in optimizing and sustaining yield, stock management and conservation of genetic diversity. The work being undertaken in the biotechnology division of CIFA involves molecular genetic characterization of Indian major carps using different types of DNA markers.

4. Gene Mapping

Gene mapping is the process of establishing the locations of genes on the chromosomes. Gene mapping is done for localization and functional characterization of economically important trait that will improve the breeding program through marker-assisted selection (MAS). The work involves isolation and development of highly polymorphic type-II DNA markers and, subsequently. Development of a genetic linkage map for Indian major carps with particular reference to *L. rohita*. The long-term objective is the identification of trait-associated genes such as disease resistance and body growth.

At present, CIFA in collaboration with ICLARM, is undertaking studies for the utilization of DNA fingerprinting in *L. rohita* breeding program to: (1) determine DNA profiles of selected, unselected and control stocks of *L. rohita* being investigated under the selective breeding program; (2) correlate performance with DNA markers within the sampled groups for future use in MAS; and (3) determine genetic tags for breeding programs.

Conclusion and Future Genetics Research

The effective management of genetic resources, risk assessment and monitoring can help promote responsible aquaculture by increasing production output and efficiency and help minimize adverse impacts on the environment. Genetic improvement program can help in development of breeding programs for important aquaculture species, can improve disease resistance and flesh quality of fish. Genetic improvement program can also provide a suitable platform for genetic research in fisheries sector and dissemination of research outputs to end-users.

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